2015-2018 PhD position in photonics

Structures de polarisation dans les lasers et réinjection : application à la réfraction conique et à la génération de faisceaux opto-hyper

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Polarisation distribution in lasers and feedback: application to conical refraction lasers and to the generation of optically-carried microwaves

Context and main objectives

At the Institute of Physics of Rennes (IPR), new architectures of multimode lasers, such as two-frequency lasers, are realized for microwave photonics. Indeed, such lasers lead to the emission of optically-carried microwave signals, based on the stabilization of the beating between several laser modes. These sources can then find application in radars, radio-over fiber communications or THz wave generation. At the same time, the study of these sources also opens some fundamental questions in the field of coupled oscillators' dynamics. Recently, at IPR, preliminary studies have demonstrated the oscillation of a multi-frequency and multi-polarization laser, based on conical refraction [1]. These kinds of oscillators have been described in the literature since only 2010 [2]. In parallel, other types of oscillators based on monolithic dual laser diode are also under study [3], in the framework of an established cooperation.

The PhD work consists first in studying, experimentally and theoretically, the dynamics of the lasers described above, in particular the conical refraction laser. Indeed, the usual interpretation of the intracavity modes based on the spatially separated eigenmodes [4] will have to be extended. A theoretical model has to be developed in order to predict the evolution of the intracavity field, and to be compared to the experimental observations. Second, stabilization schemes by frequency-shifted optical feedback that we have been demonstrated at IPR [5] will be tested on these lasers. Possibly new stabilization schemes will be investigated. Theoretical models will be developed in order to understand the role of the different parameters, such as the delay, and optimize the results. These studies, within the frame of nonlinear dynamics, will permit to validate new stabilization schemes for opto-microwave sources.

[1] O. Gobron, Mémoire de stage Master Photonique (Rennes, 2013).
[2] A. Abdolvand *et al* ., Opt. Express **18**, 2753 (2010) ; R. Cattoor *et al.*, Opt. Lett. **39**, 6407 (2014).
[3] F. Van Dijk *et al.*, Proc. IEEE Int. Top. Meet. Micr. Phot., Singapore, p. 73 (2011) ; L. Wang *et al.*, Electron. Lett. **50**, 451(2014).
[4] F. Bretenaker *et al.*, J. Opt. Soc. Am. B 8, 230 (1991).
[5] J. Thévenin *et al.*, Phys. Rev. Lett. **107**, 104101 (2011) ; M. Romanelli *et al.*, Opt. Express **22**, 7364 (2014).

Candidate profile

The candidate will hold a Master Degree on Sep. 1st 2015. Solid bases in optoelectronics are expected. Some notions of signal theory, modeling and nonlinear dynamics will also be appreciated. The subject is open and will be adapted to the profile of the student, who could focus more on experiments or on theory depending on his/her preferences.

Supervision and funding

Fellowship: French Ministry of Higher Education and Research.

Host laboratory: Institute of Physics of Rennes, UMR Univ. Rennes 1 - CNRS 6251, France.

Advisors: Pr. Marc Vallet, Institute of Physics of Rennes (marc.vallet@univ-rennes1.fr)
Dr. Marco Romanelli, Institute of Physics of Rennes (marco.romanelli@univ-rennes1.fr)

Collaboration: this research will be partly funded by the Contrat de Plan Etat-Region "Sophie" and by a European project. The project will benefit from an established collaboration with Thomas Erneux (Theoretical Nonlinear Optics group of the Université Libre de Bruxelles).

Application: includes a curriculum, a complete transcript of notes and ranks, a letter of motivation, as well as references of at least one advisor. Full application must be mailed to Marc Vallet within a zip–type file.

Keywords: **Lasers, microwave photonics, nonlinear dynamics.**